XXIII.—*On the* Upupidæ *and their Relationships.*

By Dr. James Murie, F.L.S. &c.

(Plates V., VI., & VII.)

I. *Retrospect, embodying researches and opinions concerning the Hoopoes.*

1. *As grouped in conjunction with or near the Hornbills.*—Some five and thirty summers have come and gone since Mr. Gould originally suggested the relationship of the Hoopoes to the Hornbills, an idea which took root and fructified under its foster-parent, Mr. Blyth. With the observations and remarks of the latter, then, I propose to approach the group. When treating of the "Bucceroides, or the Hornbill and Hoopoe tribes," Mr. Blyth* introduces his topic by a succinct résumé of the reasons which have caused him to look upon these as two allied tribal families. The skeleton, he conceives, separates them from the Cantores, as do the digestive and vocal organs. The heart-shaped tongue, the elongation of the beak, and the fetid liquid fæces show agreement between the Hoopoe and Hornbill. Their first plumage resembles that of the adult, and is not renewed till after the following breeding-season. They are equally Old-World groups, and possess only ten tail-feathers. He then proceeds to treat of the special characteristics of the Appendirostres (Hornbills), and subsequently reverts to the Arculirostres (Hoopoes). Of the latter he particularizes points in the sternal formation, alludes to the stomach as a membranous bag, short widish intestines destitute of cæcal appendages, and infers from these characters and from the smaller number of rectrices that they must be separated from the Certhiadæ, Promeropidæ, &c. Mr. Blyth further goes on to show that the intelligence of the Hoopoe, its lively energetic manners, its Lark-like gait, its habit of striking with the bill, together with the structure of the latter, its cœnodactyle foot (*i. e.* outer and middle toes only basally united), and propensity to climb, like the Woodpecker, all carry it away from the Hornbills, and probably from all other Syndactyli. He appears to have watched

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* Mag. of Nat. Hist. (Charlesworth's) New Ser. 1838, vol. ii. p. 589.

and studied carefully the habits of the bird in question, and brings together within a short compass much information, quoting Temminck, Bechstein, the Bishop of Norwich, Smith, Selby, Buffon, and the Earl of Derby. To peculiarities and inferences from habits I shall again take occasion to refer.

The most original researches of Nitzsch[*] mark an epoch in bird-lore; and one never turns over a page of his investigations into plumage without feeling his debtor. He refers three genera to his family Lipoglossæ, viz. *Buceros*, *Upupa*, and *Alcedo*. These agree in the absence of an after-shaft on the contour-feathers, and in the feathered tip of the oil-gland, but differ in tract-distribution and in other characters of plumage. Ten rectrices connect the two former; twelve distinguish the latter, as does a dense downy covering of the integument. The feather-tracts in *Upupa* are narrow, resembling *Galbula* in this respect; the dorsal tract is uninterrupted, but, dividing into two limbs, encloses an elliptical spinal space; the neck below has posteriorly furcate lines with broader pectoral offshoots; the main lines abdominally run back to near the anus. Remiges 20, the 1st small, the 2nd equal to the 7th, 3rd, 4th, and 5th longest. The oil-gland is peculiar and composed of two halves. In the ♀, at the breeding-season, and in the nestlings a disagreeably odoured blackish fluid obtains in the gland. There is a broad snow-white skin at the angle of the mouth in the young, in which respect they resemble the Passerinæ and not the Picariæ. He observes of *U. africana* and *U. erythrorhyncha* (=*Irrisor*) that, except that the former possesses 19 remiges, the 4th, 5th, and 6th longest, the pterylographic characters coincide with those of *U. epops*.

The Hoopoe, in the eyes of Nitzsch, seems to have been a more than usually interesting form; for he worked out its internal anatomy with some care in a memoir, which, after his demise, Giebel[†] wisely gave to the world. Anatomical work by such an able ornithologist might well bear a full translation; but for my purpose it is enough to cull the more important points. Of the muscular system, he records that it is uncommonly Passerine in kind, taken as a whole, with, however, some distinctions. The disposition of the tendons and bony grooves predisposes the similitude above stated. He describes the short triangular tongue and the presence of a pair of glands at the sides of the chink of the glottis. There is no crop; the stomach is saccular and soft; cæcal diverticula are absent; a single left carotid artery alone obtains. Other features of the lungs, liver, kidneys, nasal glands, &c. are passed in review.

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[*] 'Pterylographie,' the English edition of which is that at my command: Ray Soc. 1867.

[†] Zeitschrift f. d. ges. Naturwiss. Halle, 1857, Band x. p. 236. In vol. xi. (pl. i. fig. 34) of the same publication Giebel gives an outline of the Hoopoe's tongue in comparison with other forms.

Bonaparte* held views widely distinct from Strickland on this subject, inasmuch as, whilst apparently regarding the Hoopoe as affine to the Hornbill, he threw apart the Irrisors. Concerning the former the arrangement adopted runs—Musophagidæ, Upupidæ, Bucerotidæ, Rhamphastidæ, Leptosomidæ, Cuculidæ. His Upupidæ embraces two genera, *Upupa* and *Fregilupus*, the first with three and the second with but one species. In another section come the families Cœrebidæ and Promeropidæ, then the family Irrisoridæ, and subfamily Irrisorinæ, containing the genera *Irrisor*, *Rhinopomastus*, and *Falculia*; then the families Epimachidæ and Paradiseidæ.

Upon purely osteological data, Mr. Eyton† makes a family of the Bucerotidæ; and this contains three subfamilies—the Momotinæ, Upupinæ, and Bucerinæ. *Irrisor* he takes no notice of; but his short characters of the cranium &c. of *Upupa* (*U. epops*) are explicit enough—though, quoting others, I dispense with them.

Huxley's grand Balaclava charge at the birds‡ led him to toss the Upupidæ among Coccygomorphæ, with group "*c*, the second, third, and fourth toes turned forwards, the first backwards." He does not seem to have given much attention to *Upupa*, his remark thereon being confined to the following terse sentence:—"Here the postero-external angle of the palatine is elongated into a slender pointed process. The septum is ossified and unites with the maxillo-palatines, which form a transverse bony rafter across the palate."

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* Conspectus Generum Avium.

† Osteologia Avium, 1867, p. 59.

‡ P. Z. S. 1867, p. 447 and p. 467.

Several other writers incidentally refer *Upupa* to the Hornbill family; but it is not necessary to refer to them.

2. *Considered in the light of a distinct group.*—Under the present section I may as lief refer to the able paper of Mr. Strickland *—though, according to his own showing, the Upupidæ as consistently belong to the next. He first gives reasons wherefore the genus *Irrisor*, Less., ought to be adopted, and then compares agreement and differences between *Upupa* and *Irrisor*. The Hoopoe's ground-habits are opposed to those of the arboreal *Irrisor*; but notwithstanding this and contrast in the plumage, he sees close links of affinity between them. The similarity in the structure of their beak and tongue, he holds, is important. The lower mandible is solid, not grooved for the reception of a lengthened tongue as in the Nectarinidæ. Both upper and lower mandible coincidently in the Hoopoe and Irrisor have apically and superficially a peculiar grooving, single, however, in the former, and double in the latter bird. They both nidificate in hollow trees. Wings similar, primaries graduated, 4th and 5th longest. There is a certain counterpart in the white patches on the remiges and rectrices, although the style of colouring and difference in the form of the tail suggest generic and, occasionally, specific importance. With the feet he admits a difficulty, though he thinks these neutralized by beak &c. He places *Upupa* and *Irrisor* in juxtaposition, family Upupidæ, subfamilies Upupinæ and Irrisorinæ.

In reply to the question of the position of Upupidæ he remarks:—"They certainly are a very insulated group, forming what in geology would be termed a *remote outlier*; and it is not easy to say to which of the more continental masses they most nearly approximate." He considers them to be remote from the South-American family Certhiidæ, the likeness being only one of analogy. He concludes, "this question cannot, I think, be answered satisfactorily till more facts are collected respecting the food, habits, and anatomy of this group and of others with which it may be compared. It may, however, be conjectured that they are allied in one direction by means of *Epimachus* or *Astrapia* to the Paradiseidæ, and in another by *Merops* to the Alcedinidæ, as shown in Ann. Nat. Hist. vol. vi. pl. 8*, and as originally suggested by Vigors in Linn. Trans. vol. xiv. p. 466. In a third direction they are perhaps connected through *Lamprotornis* with the Corvidæ."

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* "On the structure and affinities of *Upupa*, Linnæus, and *Irrisor*, Lesson," Trans. Brit. Assoc. 1843, also Ann. Nat. Hist. vol. xii. p. 238, and collected works, "Memoirs," 1858, p. 418.

L'Herminier has been credited with having characterized the Hoopoes by sternal formation; but in my search through his articles in the 'Comptes Rendus' and 'Annales' I failed to discover definite statements thereon. I may say, however, that his "Recherches sur l'appareil sternal des oiseaux" I could not lay hands on in our London libraries, the memoirs appended in the footnote having alone been examined by me†.

M. Blanchard‡ observes that the Hoopoes constitute a very restricted group, but so markedly characteristic that it is impossible to join them to other types. Their sternum only distantly resembles that of other birds, the Finches to wit. In his description of the sternum he points to its elongation and high keel, which quite posteriorly has a little (triangular) flattening continued forwards some distance. The keel anteriorly is rounded or arched; a salient episternal process or nipple-shaped rostrum surmounts it, having a most singular perforation at its root. The interior is shorter than the exterior; a large pneumatic foramen is situate mesially forwards, a marked elevation bounding it anteriorly. In general contour there is a certain middle compression with regular curved sides. The coracoid facets are salient, with deep gutters, and are continuous but for the perforated rostral septum. The large obtusely pointed and obliquely set costal processes have a backward tilt and five rib-facets. There are only a pair of deep xiphoid notches, the external processes having enlarged tips; and he specially calls attention to two pointed denticles at the posterior margin of the middle piece. Basing judgment on the posterior sternal configuration, excepting the two denticles above spoken of, according to Blanchard it agrees directly with the Finches; but anteriorly there are striking differences. The development of the keel inclines to Finches, but there are other points in perfect contrast; in the Hoopoe the rostrum is obtuse, in the Passeraux acuminate.

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* Map of the Alcedinidæ, wherein *Upupa* is included, and in the above assigned position.

† "Recherches sur la marche de l'ossification dans le sternum des oiseaux," &c., Comptes Rendus (1836), vol. iii. p. 12; Ann. Sci. Nat. vi. p. 107; Comptes Rendus (1837), iv. p. 565; Ann. Sci. Nat. (1837) vii. p. 181. Since the above sentence has been in print Mr. Salvin has laid before me for inspection L'Herminier's memoir above alluded to. Therein (p. 60) the Epopsides (17th family) connect the Picidæ and Passeres; but so distinctive does L'Herminier consider the sternum of *Upupa*, that he separates it from the latter, giving rank accordingly. He concludes, "Les huppes d'une part, les promérops de l'autre, appartiennent à cette famille, à laquelle peut-être se rapportent aussi les tichodromes, les épimaques et les picucules."

‡ Annales des Sciences Naturelles, 1859, 4th ser. tom. xi. p. 111.

In allusion to *Irrisor* he mentions that the skeleton examined by him was in bad condition, but sufficient in his opinion to justify assigning to this genus close affinity to *Upupa*. His remarks on the sternal characters I shall not quote, as further on I treat of this and other bones not hitherto described. Blanchard names the genera *Fregilupus, Lamprolophos, Rhinopomastus,* and *Falculia* as having great interest from probable relationship to the Hoopoes and Irrisors; but their osteology he was ignorant of.

The superior rank and isolated character of the Hoopoes have been indorsed by another excellent naturalist and countryman of the above, Prof. Alphonse Milne-Edwards*. Reserving for a future communication his reasons for adopting the subjoined classification, he thus subdivides the Passeres:—1. Aedorninæ (=Oscines, Bonap.); 2. Epopsinæ; 3. Ocyptilinæ (=Cypselidæ, &c.); 4. Syndactylinæ; 5. Dyscampterinæ (=Musophagidæ); 6. Trogoninæ; 7. Phlœodrominæ (=Picidæ, Rhamphastidæ, &c.). Respecting the Hoopoes he urges, "Les Epopsinæ ont été parfaitement caracterisés par Lherminier, ils ne renferment que le genre Huppe, auquel M. Blanchard a adjoint les Irrisors."

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* Oiseaux Fossiles, tom. ii.

Almost every segment of the skeleton of the Hoopoe has been descanted on by Milne-Edwards with a certain brevity as to characteristics compared with the Aedorninæ. I shall avail myself of his labours, inasmuch as they may abbreviate my own, adding, however, in another section such osteological items as he has omitted or cursorily touched on. The subjoined is a free translation, and in a different order from his paragraphs. The paging after each quotation refers the reader to the original; the subsidiary headings are my own.

Skull.—In the Hoopoes, which on account of the form of the beak have been classed with Promerops by most zoologists, the osteological characters furnished by other parts of the cranium are, on the contrary, very different. The occiput, in place of being uniformly rounded, is bilobed, and the longitudinal depression which separates them into two portions is continuous anteriorly with the frontal depression. The interorbital region is very large; but the supramandibular parts are still more so, and the descending branch of the lachrymal bone detaches itself in a remarkable manner. The nasal orifices commence near to the frontals on the superior aspect of the beak, and afterwards descend obliquely upon its sides; instead of being single, as ordinarily, they are divided into two portions by a transversely oblique lamina. As in the Aedornines, the temporal grooves are very shallow and the occipital crests feebly indicated (p. 360).

Sternum and Shoulder-girdle.—The remarks of Blanchard on these parts, already given, may supplant what Milne-Edwards curtly says thereon (pp. 334, 340, 343, 346).

Humerus.—It differs much from that of the Aedornines: one never observes the median tubercle for the insertion of the long extensor of the manus; and the supracondylar tuberosity, when it exists, is not surmounted by a little projection. These latter points suffice to characterize the humerus of the Hoopoes, which besides resembles much that of the Aedornines.

Ulna.—This is very lengthened and rather slender. It presents a certain resemblance to that of the true Passeres, but it is distinguished by diminished prominence of the muscular impressions and tubercles for the insertion of the large wing-feathers. The olecranon process is long and conical, and the articular carpal extremity is much less in size (p. 352).

Metacarpus.—An intermetacarpal apophysis is absent (p. 356.)

Pelvis.—The anterior portion is much flattened, and the vertebral gutters, open their whole length, are much enlarged anteriorly by following the internal curvature of the ilia; the iliac fossæ are remarkably small. The cotyloid segment is large and short; there is a small median sacral crest; and the ilio-sciatic surfaces bulge slightly above the supraischiatic crests; the latter are salient and present behind their foramen a small denticular crest. The ischial blades spread out but slightly; and their postexternal angle, marked by deflected outside, is prolonged only to a very moderate extent. The body of the anterior sacral vertebra is furnished below with a median crest; and the renal fossæ are completely confluent (p. 321).

Femur.—Very short, and its extremities are comparatively narrow. The inferior condyles have a flattened character. Lastly the femoral head is almost sessile.

Tibia.—In the Epopsines (that is to say, the Hoopoes and the Irrisors) the tibial crests superiorly have little prominence; the shaft is cylindrical, its inferior extremity enlarged, but remarkable on account of the small development of its condyles. Finally, there appears only a trace of groove for the digital extensors, which run under a tendinous bridge; and this, tardily ossified, is always narrow and diminutive (p. 312).

Tarso-metatarse.—The foot is constructed upon a different plan from that of the Aedornines. The tuberosity is ampler, and perforated by a single tendinous foramen. The knuckle of the internal toe, in place of conforming to the plan of the others, is thrust slightly backwards. The inferior end is large, open, and approaches close to the digital condyles (p. 303).

3. *Where and wherefore ranged with the Sparrow Tribes.*—Among authorities the names of Linnæus and Brisson take us back quite a century, to the infancy of systematic ornitho-

logy. In the 12th edition of the 'Syst. Nat.' we find the Picæ containing *Trochilus, Certhia, Upupa, Glaucopis, Buphaga, Sitta,* &c., a subsection with gressorial feet including *Buceros, Alcedo,* &c. Brisson[*] puts *Upupa* and *Promerops* in his birds of the 7th order—"le bec menu, et un peu courbé en arc;" and before it come the Beef-eaters and Starlings, and after it the Swallows. Illiger's[†] Ambulatores comprise Angulirostres (*Alcedo, Merops*), Suspensi (*Trochilus*), Tenuirostres (*Nectarinia, Tichodroma,* and *Upupa*), and Pygarrhichi (*Certhia, Dendrocolaptes*). Vieillot[‡] puts the Epopsides as the 23rd family of this Tribe, Anisodactyles, after Anthomyses (Colibri), and before the Pelmatodes = Bee-eaters and Kingfishers. Koch[§] adopts as orders *Picus, Sitta, Alcedo, Certhia, Upupa, Coracias, Oriolus, Corvus.* Cuvier[||] under his Tenuirostres ranges *Upupa, Promerops,* and *Epimachus.* These come after the Rollers and Birds of Paradise, and precede the Syndactyli. Temminck's[¶] order Anisodactyles, in which *Certhia, Tichodroma,* and *Upupa* find place, was followed by the Alcyones *Merops* and *Alcedo.* Latham's[**] Picæ nearly corresponds with that of writers of the period. With Wagler[††] *Epimachus* and *Upupa* come after the Toucan &c., and before the Piapec. Lesson's[‡‡] family "Les Upupées" contains of genera *Epimachus* (*Ptiloris*), *Falcinellus, Promerops, Upupa, Fregilupus, Fregilus, and Corcorax.*

In his classification of birds[§§] Mr. Swainson places *Upupa* between *Promerops* and *Epimachus,* the three forming his subfamily Promeropidæ, which follows the Humming-birds (Trochilidæ), and precedes the Paradise-birds (Paradiseadæ), the whole constituting a family of the tribe of Tenuirostres (Suctorial birds). He remarks, "the Hoopoes (Promeropidæ) betray so close a resemblance to the Bee-eaters, that there can be no reasonable doubt of their affinity." He further says that the Grand Promerops of New Guinea, inhabiting the same regions as the Paradise-birds, from analogy, may be thought to unite that beautiful family with the Hoopoes.

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[*] 'Ornithologie.' tome ii. p. 453.

[†] Prodromus, 1811.

[‡] Dict. d'Hist. Nat.

[§] System der Baierischen Vögel, Zoologie, von Karl Ludwig Koch, 1816.

[||] Règne Animal.

[¶] Manuel d'Ornithologie, 1820, 2nd ed. pt. i. p. 414.

[**] History of Birds, 1822.

[††] Systema Avium, 1827.

[‡‡] Traité d'Ornith. vol. i. p. 319.

[§§] Cabinet Cyclopædia, vol. ii. p. 143, and p. 331.

In the well-known 'Genera of Birds,' (1849), George Gray assigns the Upupidæ location as a group of the Tenuirostres, in proximity to the Meropidæ and Promeropidæ. His 'Hand-list of Genera and Species of Birds,' 1869, pt. i., shows a slight alteration, inasmuch as the Galbulidæ intervene between the Upupidæ and Meropidæ. In his Upupidæ there are three groups—1. Upupinæ, 2. Irrisorinæ, 3. Epimachinæ. The first contains *Upupa*; the second, *Irrisor*, with the rejected subgenera *Lamprolophus*, *Cyanepops*, *Scoptelus*, and *Rhinopomastus*; the third gathers under its fold *Ptilornis* (and the discarded subgenus *Craspedophora*), *Epimachus* (*Seleucides* and *Semioptera*), and *Falculia*.

In the 'Ornithologiska System'[*] of Professor Sundevall the Oscines ambulatores contain three:—1. Paradisides; 2. Epimachides; 3. Corvides. As genera in No. 2 there are *Epimachus*, *Irrisor*, *Rhinopomastus*, *Arachnothera*, and *Upupa*. The same author, 'Svenska Foglarna' (1856), groups subsidiarily by foot-structure, and looks upon the Hoopoe as allied to the Larks. My attention, furthermore, has been called by Dr. Sclater to a still more recent work[†] of Sundevall's. The publication in question is as yet incomplete; but that published contains sufficient for my present purpose. The order Oscines holds precedence and place. First come the series Laminiplantares, divided and subdivided into cohorts, phalanxes, families, and genera. Its cohorts are Cichlomorphæ [Thrushes], Conirostres [Finches], Coliomorphæ[‡] [Crows], Certhiamorphæ

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[*] In K. Vet. Akad. Handl. Stockholm, 1835.

[†] Methodi Naturalis Avium disponendarum tentamen; Försök till Fogelklassens Naturenliga Uppstallning: Stockholm, 1872.

[‡] In ignorance of Professor Sundevall's having already adopted the term Coliomorphæ for the Crows (as a group), I used the self-same term in recognition of the peculiarities and aberrance of the genus *Colius* (see 'Ibis,' July, 1872, p. 278). Priority resting with Sundevall, I herewith cancel my use of the name, and propose instead the term PAMPRODACTYLÆ ="having *all* four toes in front" (*παμ*=*πᾶς*, *omnis*; *πρὸ*, *antè*, vel *præ*; *δάκτυλος*, *digitus*), for the Coliine group.

[Creepers], Cinnyrimorphæ [Sunbirds], Chelidonomorphæ [Swallows]. The second series Scutelliplantares has for cohorts Holaspideæ [Larks and Hoopoes], Endaspideæ [Tree-runners], Exaspideæ [Tyrant Shrikes and Todies], Pycnaspideæ [Chatterers], Taxaspideæ [Bush-Shrikes and Lyre-bird]. By this collocation Sundevall clearly throws apart the Irrisors and Hoopoe, still associating the former with the Crows and Paradise-birds, the latter with the Larks.

M. Le Baron de la Fresnaye* also regarded *Upupa* as having affinities with the Larks, but more strongly connected with *Upucerthia, Irrisor* belonging to the Sunbirds. Enough has been said to show how diverse are the opinions of ornithologists† on this subject.

II. *Additional data, structural and otherwise, bearing on the Upupidæ and pseudo-genera.*

1. *Upupa.*—My copious allusions to and quotations of prior labours on the common Hoopoe, both as to its exterior and interior, plainly debar me from having much to say thereon. Withal a few points may bear annotation, and a word on *U. minor* may be of interest.

As regards *U. epops*, specimens examined on my own account indorse Nitzsch's pterylographic remarks. In one adult ♂ I specially noted primaries 10 (5th the longest), secondaries 8, rectrices 10. Oil-gland large, broader than long, and tipped with a considerable bunch of feathers. No trace of powderdowns. Viscera, excepting length of gut, agreeing with what has been related.

Of vertebræ there are 12 to the neck. The 13th bears a tiny riblet, and therefore may be reckoned along with the dorsal;

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* P. Z. S. 1840, p. 124.

† I may further observe that Drs. O. Finsch and G. Hartlaub (Von der Decken's 'Reisen in Ost-Afrika,' vol. iv.) place the Hoopoes, Promerops, and Creepers among the Tenuirostres. Their Upupidæ comprise *Upupa*, viz. *U. epops* and *U. africana*; *Irrisor*=*I. erythrorhynchus*, *I. minor*, *I. cyanomelas*, and *I. aterrimus*. They moreover do not recognize five species of *Irrisor*,—*I. sibilator*, Vieill., *I. caudacutus*, Vieill., *I. lamprolophus*, Wagl., *I. cœruleus*, Vieill., and *I. cyaneus*, Vieill.

including it and a rearward one partially anchylosed with the ilia, 7 necessarily belong to the back. There appear to be about 10 vertebral elements coalesced into the sacral piece, and behind that 6 caudal vertebræ. In this light the spinal formula would be C. 12, D.-L. 7, S. 10, Cd. 6=35.

Eyton tabulates 11, 8, 10, 6 to the same species.

The anterior riblet is slender, styliform, 0·2 inch long. The 2nd rib, with better-defined head and offshoot to transverse process, has a length of 0·6 inch; its apex free. The 3rd, 4th, 5th, and 6th costæ bear median recurrent processes. These are wanting in the 7th and 8th, the latter rib being very slender and shorter than that which precedes. 3rd to 7th ribs have a sternal union; midway between the recurrent and transverse processes the same ribs broaden out considerably.

I may specially call attention to the great length of the slender pubic rod, and to the terminal tail-vertebra, the spinous process of which is very high and tapering.

The quadrate bone is also worthy of note; the limbs only moderate as to length. The upper articular or tympanic limb is distinguished by being longitudinally deeply guttered on its external border, a condition by no means of common occurrence. The lower articular or mandibular superficies, as more ordinarily is the case, presents three condylar knuckles; these, however, are nearly on the same plane, or with only very shallow sulci indeed between. Thus the two outer are in a manner fused together and form a backward scroll, while the single inner is laterally compressed and very narrow towards its junction with fellows.

The tongue-bone or hyoid comprises its usual avine elements. The arrow-headed or Λ-shaped tongue-pieces apically are cartilaginous; the posterior terminal forks osseous. The middle continuous piece (glosso-, basi-, and urohyals) has a long tapering dagger-outline slightly expanded and indented for the articulation of the posterior side rods (ceratohyals). What markedly denotes the hyoid of *U. epops* from that of *U. minor* is not only a relative elongation of the median segments, but its anterior end tapers, whereas in the latter it is more expanded and cleft (compare figs. 61, 62, Pl. VII.).

Lengths of the bones of the extremities of the adult female Hoopoe (*U. epops,* shown in Pl. V.) in inches and decimals :—

	Humerus.	Ulna.	Metacarpus.	Mid phalanges.	Tot. length.
Wing	1·4 inch,	1·85	0·8	0·55	4·6

	Femur.	Tibia.	Tarso-metatarse.	Mid-toe phalanges.	Tot. length.
Leg	0·95 inch,	1·5	0·9	0·8	4·15

Through the goodness of Prof. Alfred Newton I am enabled to describe, compare, and, I believe, for the first time figure the sternum and shoulder-girdle* of the South-African Hoopoe, *Upupa minor* (Gmel.). It distinctly exhibits variation from the common European species, whilst stamped with a like generic type.

Bearing in mind the distinctive characteristics of parts in that of *U. epops* as expounded by Blanchard (*anteà,* p. 185), I may state of the breast-bone of *U. minor,* that relatively it is a shade narrower, the slenderer xiphoid processes less horizontally placed, and the interior surface by no means so shallow. The posterior notches (xiphoid spaces) are a trifle greater and show no signs of forming foramina. The keel, with similar curvilinear outline, is most decidedly deeper throughout. As to the rostrum, perforation† at its base between the coracoid grooves and in these gutters themselves, the tendency to change is appreciable, but difficult to define. The bones of the shoulder-girdle, including furcula, are not so strong in *U. minor* as in *U. epops*; but it is noticeable that while the scapula in each is of equal length, the coracoid of the former is both considerably shorter and less expanded inferiorly.

The tongue-bones of *U. minor* I have already incidentally mentioned.

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* No 776*a*, Newton's MS. Osteol. Cat.

† In allusion to this foramen Mr. Parker (Ray. Soc. Monog. 'Shoulder-girdle and Sternum in the Vertebrata,' 1868), speaking of *Buceros albirostris,* observes:—"In the latter species we have a beautiful morphological character—namely, a fenestra, tending to cleave the rostrum off from the rest of the entosternum—a character better developed in *Upupa,* and very constant in most of the Gallinæ." p. 173. (See his pl. xiii. fig. 15, of fledgeling *U. epops.*)

According to the researches of Messrs. Sharpe and Dresser*, made upon a large collection of European, African, and Asiatic birds, there are but five good species, to wit, *Upupa epops*, Linn., *U. indica*, Layard, *U. longirostris*, Jerd., *U. africana*, Bechst., and *U. marginata*, Peters. As regards specific differences and validity thereof the subject is not one for me to notice; nor does their capital *résumé* of the Hoopoe's migrations and habits strictly fall within the limits of the present paper. My old colleague, Mr. Bartlett, also relates to me many interesting observations on his part, which space compels me to omit. He believes *Upupa* to be related to some forms of the Bucerotidæ, if external characters, habits, &c., are to be relied on.

2. *Irrisor*.—In a living state, from the accounts of travellers, and in the skin, this purely African group is fairly known. The sternum likewise has been said to approach that of *Upupa*; but in other respects, skeletally and anatomically, their structural peculiarities have been a desideratum. It was with no small degree of pleasure, then, that I received from Mr. Sharpe material, though scanty in kind, enabling me indubitably to establish their relationship to the Hoopoes, a point hitherto rather inferred from limited data than absolutely proved. The adage of raining and pouring, in my case, applied; for almost as soon as the above was acquired, there came to hand from Prof. Newton additional bones, the species and sex in each case being authenticated; Sharpe's having formed part of Mr. Jesse's Abyssinian collection adds to accuracy.

By consulting Pl. VI. and comparing it with Pl. V., the eye at a glance will perceive the similitude and discrepancy marking the individual bones of the two genera.

The skull of the Red-billed Irrisor (*I. erythrorhynchus*) being injured behind, the occipital contour is necessarily faulty, although my restored outline, I venture to say, is pretty near the truth. In rough measurement the bill from tip to prefrontal suture (hinge-joint in some birds) is twice the length of the cranium from the latter point backwards. This agrees tolerably well with what obtains in *Upupa*, its fore

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* A History of the Birds of Europe, Part vii. Oct. 1871.

region having the advantage, in the figured specimens—although in a second skull of *I. erythrorhynchus* I have found the præmaxillæ quite, if not fully, as long as in the Hoopoe. Be this as it may, the rear cranial segment containing the brain of *Irrisor* is relatively wider, though about the same height, as in *Upupa.* The frontal sulcus is shallower, almost obsolete; hence the vertex is all but wanting in the bilobation peculiar to the Hoopoe, and so far resembles that of the Bee-eaters. The breadth of the prefrontal region by inscooping of the orbits is narrower than in either form compared, and vastly different from the condition extant in the Bucerotidæ. The præmaxillæ carry their basal width more forwards than in *Upupa*; but the shape of the beak otherwise is not unlike, that of *Irrisor* inclining to greater deflexion. The shape and position of the narial aperture and presence of supraorbital foramen almost agree in the two genera, the latter perforation, however, being smaller in *Irrisor.* In both the nasal septum is ossified, and the maxillo-palatines, with somewhat firm spongy bone, fill the body of the mouth below. A median process pouts towards the postnares, but is not sunk and grooved as in the Alcedinidæ and Meropidæ. The horizontal palatal plates are of moderate breadth, and have long postexternal spinous processes. The continuation of the palate-bones forward are more raised and outwardly tilted, leaving therefore a deeper superficial maxillo-palatine depression. Save this and a less spongy condition of the maxillary region generally, the baso-cranial formation in *Irrisor* and *Upupa* are well nigh identical. I must not omit to remark, though, that *Irrisor* is distinguished by possessing stouter pterygoids; and these are not only wider at their anterior ends, but do not meet; the postinternal palatine angles likewise are 0·1 inch short of union.

As regards the quadrate bone, the auditory limb wants the characteristic gutter of that of *Upupa.* The orbital limb tapers more, and the mandibular knuckles are more pronounced, there likewise being an accessory cusp to the inner one. The vacuity of the orbit is somewhat less rotund in *Irrisor*; but in ossification of the interorbital septum, soldering of the tear-bone (lachrymal) with the præethmoid process, and brevity of the so-called zygomatic process, no sure line of demarcation can be drawn between it and *Upupa*.

The lower jaw complies in general outline &c. with that of the Hoopoe; the posterior and internal articular processes are less pronounced; and by a short grooving of the upper surface of the posterior end of the symphysis we have indication of slight lengthening and lodgment therein of the tongue.

The sterna of three species examined by me (*I. senegalensis, I. erythrorhynchus*, and *I. aterrimus*) differ *inter se*, and, while bearing the family stamp of *Upupa*, gradually diverge from that genus.

In *I. senegalensis* the notches are converted into small foramina, and the xiphoid bars peak outwards, thus giving greater posterior breadth to the sternum, which even mesially is wider. The keel is by far shallower, with a straighter free margin, sharper and less rounded, and wider emargination forwards. Rostrum narrower, pointed, and less deflexed. The basal rostral aperture, however, is very manifest, but the tuberosity above not so dominant. *I. erythrorhynchus* has a breast-bone like that of *Upupa*, inasmuch as the notches are open though reduced. In keel &c. it is like its *confrère*; but there is duplicity of the interior pneumatic foramina, and these are situate laterally. This same specimen of Prof. Newton's bears additional value on account of the xiphoid cartilages (*c*, fig. 28) being *in situ*. From their disposition we recognize that by their ossification the notches are readily connected into foramina, and the median indented posterior border produced, as obtains in *I. erythrorhynchus* (figs. 26–27). Moreover part of the middle cartilage, ossified and dried, is what, I presume, Blanchard accentuates as the denticle peculiar to the sternum of *Upupa*; for in my specimens a tiny bit of dried cartilage was alone present at the spot indicated. The shoulder-girdle and sternum of the Black Irrisor (*I. aterrimus*) is smaller and more delicate than the preceding. The notches are deeper, xiphoid bars pedate, a bifid tuberosity above rostrum; the latter is very short, and the emargination below and production of keel almost perpendicular. In these particulars therefore it manifests Passerine tendency.

In all the three above-mentioned species of the genus the scapula more or less agrees, viz. is straightish or very slightly curved. There is no backwardly developed episternal process to the furcula, though a tiny elevation marks the inferior union of the clavicles; the upper end (so-called præcoracoid) presents a flattened discoid expansion as in *Upupa*. The coracoid is short, with a moderate shaft, its inferior end (epicoracoid) broad and outwardly expanded. At the superior extremity there is a full development of the inner extra process (mesocoracoid of Parker), and consequently a deep groove between it and the head of the bone; in *Upupa* an ossific bridge converts this into a foramen.

Irrisor erythrorhynchus, ♂.

	Humerus.	Ulna.	Metacarpus.	Mid phalanges.	Tot. length.
Wing	1·2 inch,	1·6	0·75	0·6	4·15

	Femur.	Tibia.	Tarso-metatarse.	Mid-toe phalanges.	Tot. length.
Leg	0·9 inch,	2·0	0·9	1·15	4·95

As respects the humerus of *I. erythrorhynchus*, its inferior internal condylar tuberosity is longer than in *Upupa*. The ulna and other bones of the wing agree, difference of size being taken into account.

The tibia, a longer bone with enlarged extremities, is kindred in pattern to that of the Hoopoe. The tubercle below, bony bridge, and fibular projection are all there; but it is distinguished by a greater prominence of the head, defined pouting tuberosity, and longer knife-like supero-inner ridge—all tantamount to increased grooving of the muscular impressions.

The construction of the tarso-metatarse is of exceeding interest; in it we find a repetition of those characters which distinguish and, indeed, isolate *Upupa* from other birds. *Irrisor*, notwithstanding, has points intimating commencement of divergence. The calcaneal eminence is pronounced and deeply grooved. There are two foramina at its root; but the head is wider transversely than in *Upupa*. The tendinous grooves of the shaft are better marked, and this gives greater angularity to the bone. The knuckles of the inferior end are deeply scooped, and the inner one longer; and, lastly, the metatarsal ossicle with which the hind toe articulates is lengthened compared with *Upupa*.

The digits have the ordinary number of phalanges, the distal claw-bearing ones stronger and with greater curvature than in the Hoopoe.

I have examined the pterylosis, which substantiates Nitzsch's observations. Concerning the toes I find there is adherence of the basal innermost phalanges; and the bones of same, as in the Hoopoe, have a certain coadaptation of curvature fitting the one to the other.

3. *Rhinopomastus, &c.*—In this form, irrespective of coloration of plumage, I recognize points which seem to substantiate its generic separation from the preceding. Its osteology I shall briefly advert to; for in most particulars, size excepted, it agrees with *Irrisor*.

The wing-bones require no comment. The tibia has shallower musculo-tendinous grooves; is likest therefore *Upupa*. The tarsal ridges are weaker than in *Irrisor*; the inferior articular knuckles and the hind-toe metatarsal ossicle agree. The head of the tarsus is pushed a grade further from *Upupa* and *Irrisor* in the minor prominence of the postcalcaneal eminence and shallowness of its sulcus, and in breadth to antero-posterior depth of the head. The following are the absolute lengths of the limb-bones in this specimen:—

Rhinopomastns cyanomelas, ♂.

	Humerus.	Ulna.	Metacarpus.	Mid phalanges.	Tot. length.
Wing	1·0 inch,	1·25	0·5	0·4	3·15

	Femur.	Tibia.	Tarso-metatarse.	Mid-toe phalanges.	Tot. length.
Leg	0·7 inch,	1·2	0·8	0·75	3·45

The configuration of the skull has sensibly altered from that of *Irrisor*, deflexion and tenuity of the præmaxillæ being marked and simulating what obtains in *Drepanus* and like genera. This curvature is very apparent in the lower mandible; and this bone has its postarticular angle almost vertical. The brain-section of the cranium is full, globose, and without longitudinal sulcus. The prefrontals and interorbital area are relatively broader than in *Irrisor,* and altogether higher, while evidence of suture with the bill and production of premaxillary splints is obliterated. The small nostril has no groove behind leading to supraorbital foramen—the representative of the latter being reduced to a speck. The palatine formation essentially agrees; but the spongy maxillo-palatines and ossified nasal septum are well nigh flush with the anterior palatine bars. The post-inner palatine angles are narrowed, leaving greater space between them and the long delicate external retrocurrent spines. The knuckles of the quadrate are more rounded and prominent than in *Irrisor.*

I subjoin a series of calculations affording evidence that the ratio of the bones of the limbs present a certain agreement among themselves, but yet differ in the three genera. *Irrisor* has proportionally the greatest tibia, and *Rhinopomastus* the relatively longest tarso-metatarse to metacarpus. In proportion of entire leg to wing they both exceed *Upupa.*

	Upupa epops, ♀.	*Irrisor erythrorhynchus*, ♂.	*Rhinopomastus cyanomelas*, ♂.
Ulna to humerus	132 : 100	133 : 100	125 : 100
Metacarpus to humerus	57 : 100	62 : 100	50 : 100
Mid digit to humerus	39 : 100	50 : 100	40 : 100
Tibia to Femur..............	157 : 100	222 : 100	171 : 100
Tarso-metatarse to femur	94 : 100	100 : 100	114 : 100
Mid anterior toe to femur	84 : 100	127 : 100	107 : 100
Humerus to wing............	30 : 100	27 : 100	31 : 100
Ulna to wing	40 : 100	38 : 100	39 : 100
Metacarpus to wing..........	17 : 100	18 : 100	15 : 100
Mid digit to wing	12 : 100	14 : 100	12 : 100
Femur to leg	22 : 100	18 : 100	20 : 100
Tibia to leg	34 : 100	40 : 100	35 . 100
Tarso-metatarse to leg........	20 : 100	18 : 100	23 : 100
Anterior mid toe to leg	18 : 100	23 : 100	22 : 100
Femur to humerus	60 : 100	75 : 100	70 : 100
Tibia to ulna................	83 : 100	125 : 100	95 : 100
Tarso-metatarse to metacarpus.	111 : 100	120 : 100	160 : 100
Mid ant. toe to mid dig. of wing	145 : 100	191 : 100	187 : 100
Leg to wing	94 : 100	119 : 100	109 : 100

4. *Fregilupus.*—Of this remarkable form Prof. Schlegel[*] uses words to this effect:—The species, *F. madagascariensis*, has become so rare at the island of Réunion (Bourbon) that it has not been heard of for a dozen years. Coastwards it is destroyed; but report says that it still exists in the interior forests. Old Creoles state that at one time they were common, stupid, and easily killed with a stick. It is there known by the name of Hoopoe. Whether suggested by this local name or otherwise, some ornithologists, Bonaparte for instance, have ranged it among the Upupidæ. Later writers, however, George Gray for example, more judiciously placed it in the neighbourhood of the Sturnidæ. Its proper location it is not my intention at present to enter on, my object alone being to give succinct and good reasons for its separation from the Upupidæ.

I understand that no skin of the form in question exists in this country, and that the only skeleton is that in the possession of Professor Newton at Cambridge. The kindness of this gentleman, then, in forwarding the precious specimen[†] for my examination, I duly appreciate.

Osteologically the points of departure from *Upupa* and *Irrisor* are trenchant. The keel of the sternum is relatively shallower, and anteriorly sharper; the rostrum deeply forked, large, and sharply upturned; the whole sternum is broader; xiphoid spaces longer; costal processes very high and broad. Furcula with a large inflected process or interclavicle. Scapula curved; coracoid long, narrow, and relatively slender. Pelvis with narrowed deflected ilia in front and proportionally wide behind; ischia remarkably long, their pointed tuberosities little short of the pubes. Postfrontal and occipital regions of skull full and rounded; the former relatively narrower, the latter with greater width to height; there is a large interorbital vacuity; narial orifice large, long, and elliptical; a stout vomer present, truncated in front and cleft behind;

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[*] Recherches sur la Faune de Madagascar et de ses dépendances d'après les découvertes de François P. L. Pollen et D. C. Van Dam. Mammif. et Ois. par H. Schlegel. Leyden, 1868. Part 2, p. 104.

[†] Labelled *Fregilupus varius* ♂, Réunion (J. P. Verreaux), No. 974*a*, Newton's MS. Osteol. Col.

septum of nares unossified; no union of maxillo-palatines, and a large palatal cleft. Leg-bones long, the tarsus unusually so; two outer toes cleft to the root. Tongue long, narrow, pointed, and lies in a groove in symphysis of mandible.

Whatever supposed affinity *Fregilupus* bears to *Upupa* from tenuirostral character, thus we see, breaks entirely down by skeleton-evidence.

5. *Falculia.*—My study of *F. palliata*, another of those curious Madagascar forms, is unfortunately limited to a stuffed specimen in the British Museum, and to literature on the bird. Judging from the shape, more particularly the depth of the bill, from the relatively narrowed condition of prefrontals and cranial contour, from the structure of the foot with elongate tarsus (other than plumage &c., discoursed on by ornithologists), I certainly agree with those who deny its having close affinity to the Hoopoes. It is quite possible that it may veer towards the preceding, *Epimachus*, or the next to be mentioned; but at all events outward character of itself precludes association with the Upupidæ. I must refer the reader to Geoffroy St.-Hilaire's original description[*], and to Schlegel's account[†], where the young and sexual differences and the habits of the bird are dwelt upon.

6. *Heteralocha.*—The anomalous Huia Bird of New Zealand has been referred by its original describer, Mr. Gould[‡], by Cabanis[§], G. Gray[||], Sundevall[¶], and others to the neighbourhood of the Crows, and in close proximity to the Starlings, though suggestions as to its alliance with the Hoopoes have not been wanting (to wit Gray[**]). In the latest monograph on the birds of New Zealand, Mr. Buller urges the latter position; and accordingly *H. acutirostris* (*Neomorpha*, Gould) is consigned to the Upupidæ[††]. The nidification of this bird is unknown;

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[*] Mag. de Zool. 1836.

[†] *Op. cit. suprà*, p. 105, pl. 33.

[‡] P. Z. S. 1836, p. 144; Birds of Australia, iv. pl. xix.

[§] Mus. Hein. Th. i. p. 218.

[||] Hand-list of Birds, ii. p. 22.

[¶] Meth. Nat. Avium dispon. tent. p. 40.

[**] "Birds of N. Zealand," Ibis, 1862, p. 217.

[††] From a conversation with Mr. Buller I learn that his opinion is changed as regards the affinities of *Heteralocha* since the publication of Pt. i.; and his introduction rectifies this (Hist. of Birds of New Zealand, p. xvii.).

but some of its habits, well told by Mr. Buller, certainly recall peculiarities of the Hoopoes and Hornbills. On the other hand, possession of wattles, the remarkable difference in length of the beak in the sexes, &c. weaken even exterior characters where these are relied on for interpretation of relationship.

The strongest evidence that its construction is unlike that of *Upupa* and *Irrisor* is given by its anatomy. Mr. Garrod's* recent investigation shows that coracomorph and not coccygomorph type prevails. According to him the dorsal feather-tract does not enclose an ephippial space; remiges nineteen; rectrices twelve; uropygium naked. Tongue elongated, triangular, slightly bifid apically. There are two short cæcal appendages, and a single left carotid artery. A forwardly truncate and posteriorly cleft vomer obtains; the maxillo-palatines do not meet; the nasal septum is unossified, the prepalatines leave an open wide cleft. Other points are noted; but the above in themselves are sufficient to prove attributes at variance with what pertains to the Upupidæ.

III. *Disposition of the Upupidæ weighed by their organic build.*

1. *To the Larks.*—That so great an authority as Sundevall, under the present phase of ornithology, should see fit to conjoin the Hoopoes with the Alaudinæ, and separate the former from groups truly allied, receives explanation from the false assumption of single characters being the test of systematic relation. A resemblance in tarsal scutella, and even terrestrial habit, may coexist in two forms (adaptations to certain phases in modes of life, or scintillations of a once common attribute) without these overruling the more stable organic whole as related to kindred and descent. I am willing to cede every scrap of vantage-ground to the worthy Swede, to acknowledge earth-loving habit, proneness to grovel in the dust, their crest, tenuous beak, long shank, elliptical space in spinal feather-tract, and plantar scutella, as numerical testimony that the Hoopoe has points in common with one or other of the Larks.

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* P. Z. S. 1872, p. 643.

But that these should overmatch characteristics of colour of egg, nest-building, number of rectrices, of oil-gland, vocal organs, song, tongue, cæca, sternum and shoulder-girdle, pelvis, relation of wing to leg-bones, perforate condition of head of tarsus, construction of base of skull, &c. I can by no means admit. Yet the Larks and Hoopoes differ widely in all these respects. These structures are coadapted to organic function, and of necessity evince propinquity of type. To fling such evidence to the winds, as Sundevall's late arrangement proposes, shakes my confidence entirely in its worth.

2. *To the Creepers and Sunbirds.*—As in the last, with these forms outward resemblances have too long swayed ornithologists in assigning a close proximity of *Upupa* to the Certhiadæ and Nectariniidæ. The moment we go more than skin deep the skeletal structure reveals a want of harmony between these forms and *Upupa* and its true allies. The usually long slender beak of the Creepers and Sunbirds deceives as to their Hoopoe relationship. This point kept in abeyance, I have but to repeat what has been affirmed of the Alaudinæ, to show that in a whole mass of particulars they have no common tie. In the case of *Certhia* and *Nectarinia,* moreover, they have not the advantage of likeness in plantar scutella, pterylosis, or terrestrial habit, though their beak-elongation suggests analogy.

3. *To the Starlings and Crows.*—What affinity there is between the Corvine group and the Upupidæ has never been weightily insisted upon by reason of intense similarity in outward aspect. Neither the beak nor feet of the former suggest such deceptive likeness as in the preceding groups. Strickland's hint of filtration through *Lamprotornis* has but an outer garb of cogency; for even our subsequent group 4 might stand between. As what I have to say concerning them applies equally to the present, the latter are thus twofold removed in consanguinity.

4. *To the Rifle-birds and Birds of Paradise.*—If *Seleucides albus** be accepted as one (Epimachinæ) and *Paradisea papu-*

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* For the use of a skeleton of this bird I am indebted to Prof. Newton. It bears his MS. Osteol. Cat. No. 793*a*. The Bird of Paradise I refer to is the skeleton in the gallery of the British Museum.

ana (Paradiseidæ) typical of the other, I can satisfactorily dispose of these as not being of nearest kin to the Upupidæ. In *Seleucides,* whilst the elongate præmaxilla is not unlike that of *Irrisor,* it yet differs most materially at the root, and especially depression at junction with prefrontals. There is a large interorbital fenestra. The palate is passerine, *i. e.* stout vomer and non-union of maxillo-palatines, therefore palatal cleft wide. Pterygoids long and slender. The mandibular symphysis is deeply grooved for the reception of a very long, delicate, tapering tongue, and the postarticular angle of the lower jaw truncate. Tongue-bones unusually long. There is an episternal process to the furcula; sternal rostrum large and furcate; keel sharp forwards; middle much longer than external xiphoids. Pelvis narrow anteriorly. Leg-bones of great length; four upper tarsal perforations for tendons, and other skeletal differences. In *Paradisea* most of these points in the body and limbs bear out within certain limits the contrast exhibited by *Seleucides.* The skull of *Paradisea,* moreover, as to general shape, and particularly premaxillary and mandibular peculiarities, is far more unlike that of the Upupidæ. Nitzsch has long ago shown there is a vast difference in their pterylosis. If, moreover, we supplement geographical distribution, habit, &c., distinction and separation from *Irrisor* and *Upupa* is abundantly warranted in the face of Sundevall's union.

I may here observe there is great difficulty in proving what Passerine approaches nearest to the Upupidæ; as regards the Syndactylæ the problem is easier.

The resemblances between *Promerops, Upupa,* and *Irrisor* in the form of the beak and, partly, tail have suggested their close alliance to many ornithologists. This similarity in outward aspect, however, is contra-indicated by their skeleton, which differs trenchantly. In Plate VII. I have delineated the skull and certain of the bones of *Promerops* as contrasted with *Rhinopomastus.* My notes thereon I reserve for another communication, as also the summary of characters distinguishing the Epopomorphæ, their insertion in this paper being deemed too lengthy.

5. *To the Bee-eaters, Kingfishers, Rollers, and Motmots.*—Nitzsch's Lipoglossæ certainly combines *Alcedo* with *Upupa* through pterylosis; but even in this respect important contrast obtains. Giving plumage all due importance, the above four groups, though Desmognathous (united maxillo-palatines and slender anteriorly pointed vomer as in *Upupa*), still exhibit trenchant separation. Their breast-bone is four-notched; and its shoulder-girdle and part of wing-bones manifestly show other morphological changes. The proportional length of limb-segments, difference in construction of the tibia, tarsus, and greater syndactylism, the shape and disposition of the nares, orbital, mandibular, and tongue-bone parts, and a host of such like osteological data are unlike. They usually have twelve rectrices and double carotid arteries, tongue and internal viscera departing in type; and in egg, nidification, habits, food, &c. (and still more so the Rollers and Motmots), they do not coincide sufficiently to award them claim of nearest relationship. I must say, however, that in outline of skull, and particularly disposition of bill and palate, species of *Merops* and *Alcedo* offer more than a mere passing likeness.

Such characters are aberrant lines which approach similarly tangentially specific ones (videttes) of the Hoopoe group without closest alliance necessarily supervening.

6. *To the Hornbills.*—Lastly, what in exterior appearance can be more opposed to each other than such a great unwieldy horned bird as the Rhinoceros Hornbill (*Buceros rhinoceros*) and the graceful Hoopoe? Yet patient inquiry leads apace to trace the steps of graduation. Admitting that exuberance of casque and many other external characteristics of the above-mentioned Hornbill can hardly be reconciled with the idea of family relationship to the Hoopoes and Irrisors it cannot be gainsaid that the Bucerotidæ present extremes. When *Toccus* is reached, size and outward peculiarities dwindle till we have a form in which can be recognized semblance to certain of the Upupidæ. There is still a gap; but the very manifold structural agreements and adaptations thereof to habits &c. are strong evidence of congruity. Reiteration of what has been well told by others is superfluous; it suffices

to say that economy in general, pterylosis, geographical distribution in part, and anatomy taken all in all, turn the scale in favour of the Hornbills as the group bearing the closest relation to the Hoopoes and Irrisors. Their palatal and premaxillary condition &c. vary; but withal this does not detract from the proposition as above expressed, neither does it militate against the notion that certain of the Bee-eaters and Kingfishers throw off spurs of affiliation towards the Upupidæ.

I have spoken of a gap, and I shall trespass on the readers of 'The Ibis' by suggesting what probably may fill it—the missing link. The *Cryptornis antiquus* (Gervais), a fossil form discovered in the gypsum near Paris (tertiary formation of geologists), was originally referred by Laurillard* to the Kingfishers, species of *Alcedo*. M. Gervais† afterwards adjudged to it Cuculine affinity, and designated it *Centropus antiquus*. Alph. Milne-Edwards's‡ researches in the same field led to his regarding it as more closely allied to the Hornbills, and therewith adopting for it the generic title *Cryptornis*. The latter author bases affinity chiefly on tarsal formation and proportion of some of the wing- to leg-bones. The first four lines of the accompanying Table are those of Milne-Edwards; the succeeding three similar calculations are mine.

	Tarse.	Tibia.	Humerus.	Cubitus.
Cryptornis antiquus	100	168	184	198
Centropus philippinensis.	100	150	96	80
Centropus affinis	100	148	96	82
Tockus erythrorhynchus	100	174	164	200
Upupa epops..........	100	166	155	205
Irrisor erythrorhynchus.	100	222	133	177
Rhinopomastus cyanomelas	100	150	125	156

Acknowledging the justness of Milne-Edwards's inference from proportions of limb-segments, I, moreover, may remark that the tarso-tibial relations of *Upupa* to *Cryptornis* are even closer than that of *Toccus*, though the wing is a remove further. Studying the fossil remains in question, from delineations given, and particularly Milne-Edwards's admirable representation, it seems to me that the contour of the orbito-cranial portion of the skull, the positive and negative evidence of a long, shallow, straight, pointed bill, and what is present of the rami of the lower mandible, all point as much, if not more, to *Upupa* and *Irrisor* than to the same parts in *Toccus*. The tarsal structure is quite as near *Irrisor* as the latter. When I add that likewise the ribs, even though imperfect, and unusual elongation of pubis (of the latter I presume the rod-like bone thrown rearwards out of place), show further likeness, I believe I am justified in looking upon *Cryptornis* as an extinct ornithic bridge betwixt the Bucerotidæ and Upupidæ.

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* Dict. d'Hist. Nat. Atlas, Ois. fos. pl. 2.

† Paléont. franç, 2nd ed. p. 409, pl. 49, fig. 1.

‡ Oiseaux fossiles, vol. ii. p. 371, Atlas, pl. 175.

Whilst speaking of fossils I may mention that certain fragmentary remains of long limb-bones, described by Milne-Edwards, are shown to be identical with those of *Upupa*. *Limnatornis paludicola*, Milne-Edwards, is another form believed by him to approach the Upupidæ; and *Laurillardia longirostris* evinces osteological affinities with *Merops*, *Promerops*, and *Cryptornis*. The paucity and imperfect nature of the material, however, is such that, although it permits recognition of bones as nearest to those of certain living groups, restorations advantageous for systematic purpose are less secure.

IV. *Final Considerations on the Hoopoe.*

The conclusions arrived at by me thoroughly substantiate by osteological data Strickland's juxtaposition of *Upupa* and *Irrisor*. Moreover his subfamilies Upupinæ and Irrisorinæ fitly serve to distinguish certain differentiation of character possessed by each—though, if an increased value of rank is assigned the Hoopoes, Upupidæ and Irrisoridæ must be used. In the former I recognize but one genus, *Upupa*. The Irrisoridæ contain two tolerably well-defined genera, *Irrisor* and *Rhinopomastus*, although it is possible further research among the fossil specimens may bring out others akin to these or the preceding.

I, likewise, am satisfied that Prof. Alph. Milne-Edwards's estimate of the value of the osteological characters of the group, entitling them to a separate rank, is worthy of adoption among ornithologists. The Epopinæ or Epopomorphæ would thus be segregated from Huxley's group of Coccygomorphæ, but in a linear arrangement still follow the Bucerotidæ as nearest allies. It is true I have endeavoured to show the passage-form which may break down the line of demarcation. It is highly probable that some corresponding extinct bird may yet be found blending Upupine or Irrisorine characters with Passerine, and that in this way our present grouping may fall to nought. The formation of the group Epopomorphæ must therefore be regarded only as a temporary expedient in the attempt to comprehend the natural classification of birds.

DESCRIPTION OF THE PLATES.

Plate V.

Skeletal segments of Hoopoes, viz. a female adult specimen of *Upupa epops*, Linn. (figs. 1 to 22), and three views (figs. 23 to 25) of the sternum of a male *Upupa minor*, Gmel., the latter drawn from a specimen in the osteological collection of Prof. Newton of Cambridge, and numbered 766*a* in his MS. catalogue. Figs. 5, 6, 19, and 21 are enlarged two diameters; all the rest are, as near as may be, of natural proportions.

Fig. 1. A side view of the cranium.

Fig. 2. Lower mandible, also in profile.

Fig. 3. Skull, seen from above.

Fig. 4. Palatal surface of the skull.

Fig. 5. Under articular aspect of the left quadrate bone, magnified two diameters.

Fig. 6. The same quadrate bone on its outer surface, magnified two diameters.

Fig. 7. Occipital aspect or back view of the skull.

Fig. 8. The lower jaw, seen from above or orally.

Fig. 9. The furcula or united clavicles, from in front: *p c r*, præcoracoid expansion.

Fig. 10. Under surface of the breast-bone.

Fig. 11. The articular upper end of the arm-bone.

Fig. 12. The same bone, viz. left humerus, its posterior face.

Fig. 13. Its lower articular extremity.

Fig. 14. Inner aspect of the remainder of the bones of the left wing.

Letters applicable to the above figures run:—*n*, nostril; *s o f*, supra-orbital foramen, a bony plate dividing it from the anterior nares; *p*, posterior, *e*, exterior, and *i*, inner quadrate knuckles, articulating with lower mandible; *o l*, orbital limb; *g*, groove on auditory limb of quadrate.

Fig. 15. Spine from the dorsum backwards, the pelvis, ribs, and shoulder-girdle attached: 1 & 2, foremost two free ribs; *pu*, pubis.

Fig. 16. Upper or dorsal aspect of the pelvis.

Fig. 17. The right femur or thigh-bone, from behind.

Fig. 18. Shank, viz. right tibia (*t*) and fibula (*f*), from in front.

Fig. 19. Ankle-joint or upper articular surface of tarsus, about double natural size.

Fig. 20. The right tarso-metatarse, its posterior aspect: *m*, metatarsal element.

Fig. 21. Inferior knuckled end of the same bone, but magnified two diameters.

Fig. 22. Bones of the right foot, seen from the inside: I., II., III., IV., digits respectively.

Fig. 23. Side view of the sternum of the South-African Hoopoe, *Upupa minor*.

Fig. 24. Interior (or upper) surface of the same bone.

Fig. 25. Outline or foreshortened anterior view of the same sternum. (No. 766*a*, Newton's MS.)

Letters referring to the three preceding:—*r*, rostrum; *f*, foramen at its root; *p*, process surmounting it for attachment of the coracoid ligaments; *cog*, coracoid groove; *cp*, costal process; *ex*, external xiphoid bar; *pn*, pneumatic foramen; *k*, keel.

PLATE VI.

Various bones of species of *Irrisor*, of natural size, save figs. 36, 37, 44, and 47, which are enlarged about twice their real dimensions.

Fig. 26. Ventral surface, sternum of *Irrisor senegalensis*.

Fig. 27. Interior of the same breast-bone.

Fig. 28. Under view, sternum of *Irrisor erythrorhynchus*. No. 627*a*, Newton's Osteol. Cat.; specimen forwarded him by the late Mr. Andersson from Damaraland.

Fig. 29. Furcula or united clavicles of the same specimen.

Fig. 30. Foreshortened anterior view of the sternum of *I. erythrorhynchus*. (No. 627*a*, Newton's Osteol. Cat.)

Fig. 31. Sternum of *I. senegalensis* in profile.

Fig. 32. Shoulder-girdle belonging to the above.

The lettering used in *Upupa*, Pl. V., applies to the the same parts in the foregoing, with the addition of:—*pn*, pneumatic foramen; *xf*, xiphoid foramen; *s*, scapula; *cl*, clavicle; *ep*, epicoracoid.

Fig. 33. Skull, from above, of an *Irrisor erythrorhynchus* ♂, specimen collected by Mr. Jesse (Abyssinian Expedition) at Kokai, 12th July, 1868. Specimen referred to by O. Finsch, Trans. Zool. Soc. vol. vii. p. 226, under *b* (No. 683). Occipital area in outline.

Fig. 34. Upper surface, mandible of the same specimen.

Fig. 35. Lower basal view of said skull: *m x p*, maxillopalatine.

Fig. 36. Outer surface, left quadrate, magnified two diameters.

Fig. 37. Under articular aspect of the left quadrate bone, magnified two diameters.

Fig. 38. Profile of cranium, same ♂ *I. erythrorhynchus.*

Fig. 39. Its mandible, side view.

Fig. 40. Part of the right humerus (lower end) of the *I. erythrorhynchus* from Kokai.

Fig. 41. Inferior articular extremity of the same.

Fig. 42. Remainder of wing-bones in connexion: *u*, ulna; *r*, radius.

Fig. 43. Tibia (*t*) and fibula (*f*) of the same bird.

Fig. 44. Enlarged drawing, upper articulation of tarso-metatarse, magnified two diameters.

Fig. 45. Right tarso-metatarse, from behind, natural size.

Fig. 46. Bones of the right foot and tarso-metatarse: I. to IV., digits.

Fig. 47. Diagrammatic representation of the inferior or distal end of the tarso-metatarse of ♂ *Irrisor erythrorhynchus*, double natural dimensions.

PLATE VII.

Osteology in part, and the exterior feet-characters, of genera of the Upupidæ, and of *Promerops*, representative of the Promeropidæ. Figs. 56, 57, 67, 69, and 70 are magnified, the others of natural dimensions.

Fig. 48. Upper surface of the skull of *Rhinopomastus* (*Irrisor*) *cyanomelas* ♂, spec. ex Mus. Sharpe (labelled, Ojimbinque, June 17, 1866).

Fig. 49. Upper surface of the skull of *Promerops caffer* from South Africa, also a donation from Mr. R. Bowdler Sharpe.

Fig. 50. Inferior or palatal aspect of the cranium of *Rhinopomastus cyanomelas.*

Fig. 51. Similar view of the cranium of *Promerops caffer.*

Fig. 52. Side view of the skull of *Rhinopomastus cyanomelas.*

Fig. 53. Lower mandible of the same.

Fig. 54. The skull of *Promerops caffer*, in profile.

Fig. 55. Mandible of the same specimen of *Promerops.*

Fig. 56. Right quadrate bone of *Promerops caffer*, from the outside, and twice natural size.

Fig. 57. Its inferior aspect, showing knuckles for articulating with inferior maxilla.

Fig. 58. Mandible of *Rhinopomastus cyanomelas*, its upper or oral surface.

Fig. 59. A similar view of the inferior maxilla of *Promerops caffer.*

Letters common to the foregoing figures:—*m x p*, maxillo-palatine; *vo*, vomer; *c*, cleft or fissure, maxillary and nasal; *p*, posterior angle of the mandible; *o l*, orbital limb; *o*, outer, *i*, inner, and *p*, posterior knuckles of quadrate bone.

Fig. 60. An upper view of the tongue, glottis, &c. of *Upupa minor*: *g*, gland, lateral and behind the orifice of the glottis.
Fig. 61. The cleaned hyoid or tongue-bones of the same bird (*U. minor*).
Fig. 62. Hyoidean apparatus of the common Hoopoe, *Upupa epops*.
Fig. 63. Left humerus of *Promerops caffer*, shown from behind.
Fig. 64. Left tarsus of the same bird, anterior aspect.
Fig. 65. The same tarsus posteriorly.
Fig. 66. Left tibia or mid leg-bone of *Promerops caffer*, its inner surface.
Fig. 67. The knee-joint end or upper articular surfaces of this tibia and the fibula, enlarged two diameters: *t*, tibia; *f*, fibula; *a t*, anterior tibial eminence or cnemial tubercle; *e*, external tibial tuberosity; *i*, inner tibial tuberosity.
Fig. 68. A front view of the same tibia and fibula entire.
Fig. 69. The upper end of the left tarsus of *Promerops caffer*, about twice the natural size.
Fig. 70. The lower end of the same tarsus, also magnified two diameters.
Fig. 71. Sternum of the Black Irrisor, *I. aterrimus*.
Fig. 72. Clothed tarsus and sole, right foot of *Promerops caffer*.
Fig. 73. An inner view, in profile, of the same foot and tarsus.
Fig. 74. Clothed tarsus and sole of right foot of *Rhinopomastus cyanomelas*.
Fig. 75. Inner aspect of the same limb.
Fig. 76. Sole of the left foot of the Red-billed Irrisor, *I. erythrorhynchus*.
Fig. 77. The lower limb of the common Hoopoe, *Upupa epops*.
Fig. 78. Sole and hinder surface of scutellate tarsus of the same Hoopoe: I., II., III., and IV. denote the consecutive toes in the above seven figures.

XXIV.—*Notes on 'Stray Feathers'* *. By W. T. Blanford, F.G.S., C.M.Z.S.

The appearance of a new periodical, solely devoted to Indian ornithology, and edited by Mr. Allan O. Hume, deserves more than a passing notice. Mr. Hume is not only, as he modestly states on his titlepage, the editor, but also the author of the eleven different papers contained in the only number of his magazine which has hitherto reached England. Valuable as these papers are, and important as are the additions made by them to our knowledge of the avifauna of India, the first feeling with many Anglo-Indian ornithologists will probably be one of regret that the labour spent upon this number by Mr.

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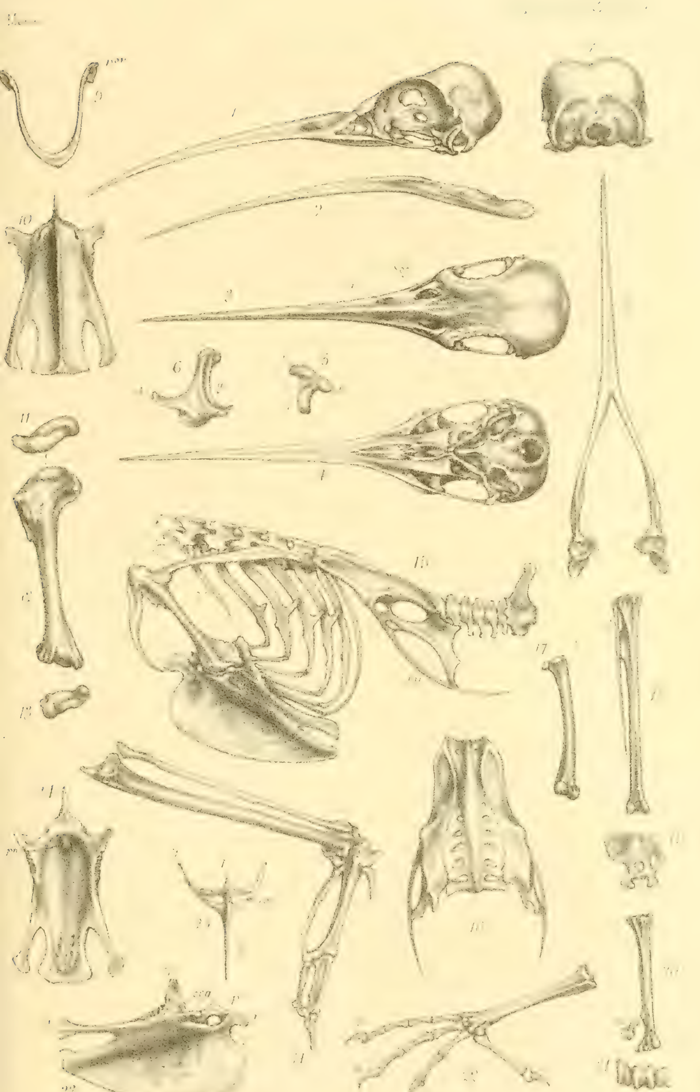
* 'Stray Feathers,' No. 1. November 1872. Edited by Allan Hume. Calcutta: T. Black & Co. London: Bumpus.



C. Berjeau lith.

UPUPA EPOPS & U. MINOR.

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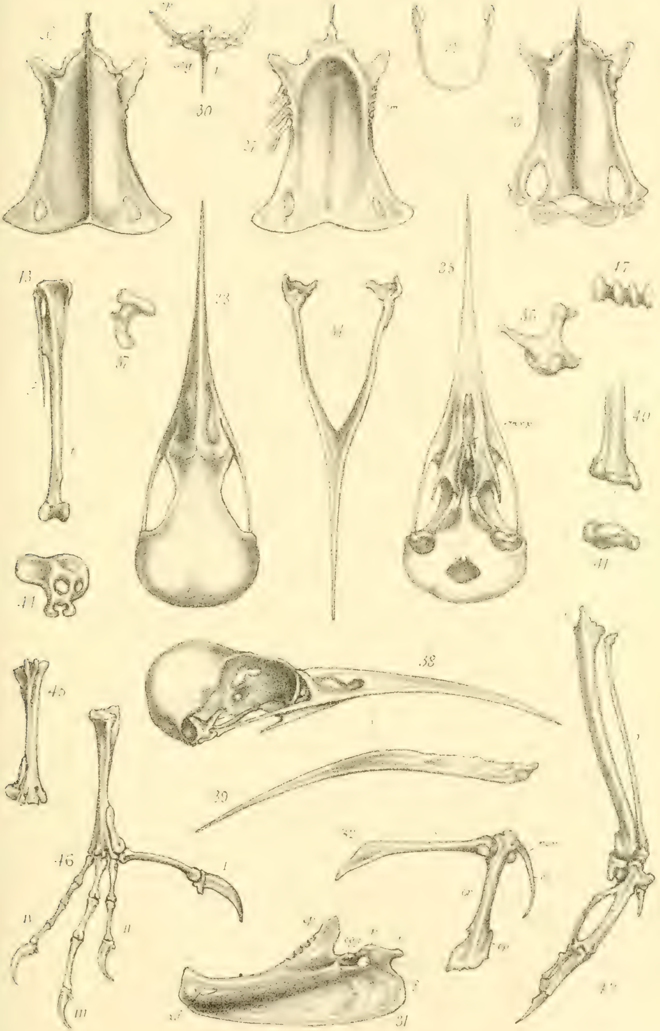

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